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Effect of cognitive training on working memory and mindful attention: A study on sportsmen

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Abstract
Background: Cognition is a key component of an individual's life that becomes even more significant for sportsmen due to the nature of the activities they participate in. The current study studied the influence of cognitive training on the working memory capacity and mindful attention ability of sportsmen.
Materials and Methods: A 3-week (21-day consecutive) self-designed cognitive training programme was administered to fourteen (N=14) male participants aged 21-23 years, who were randomly divided into two groups: experimental and control (N=7 each). The experimental group followed a 3-week cognitive training course of 15m/session, while the control group merely followed their daily routine. The study used a quasi-experimental pre-test-post-test descriptive research design.
Outcome Measures: Working memory capacity was measured using the Digit Span test and mindful attention was measured using the Mindful Attention Awareness Scale (MAAS). Paired t-test and ANCOVA statistical interventions were used, and the significance level was set at .05 levels.
Results: The findings showed that the experiment group which underwent cognitive training for 3 weeks, showed a significant improvement ($p<0.05$) in their working memory capacity and mindful attention ability.
Conclusion: The findings of the study reveals that a 3-week (21-day continuous) cognitive training programme considerably improves sportsmen's working memory capacity and mindful attention ability.

Keywords: Cognition, cognitive training, sportsmen, working memory, mindful attention

1. Introduction
The mental processes involved in acquiring information and comprehension are referred to as cognition. It involves activities such as thinking, knowing, remembering, judging, and problem solving, as well as higher-level brain functions such as language, imagination, perception, and planning [1]. The basic cognitive abilities of humans can be amplified by the means of targeted cognitive training [2-5], which has been proven in many other research works also. It is now possible to investigate not only the functional anatomy of neural networks but also the quality of the genetic variants that may contribute to individual variance in acquiring skills as well as performance [6]. Cognitive training consists of specially designed training programmes that provide supervised practise in order to improve efficiency in one or more cognitive domains [7]. In recent years, several different types of cognitive training strategies have been applied by researchers in order to target varying cognitive abilities. Sporting activities can be organised, casual, or recreational, and can be physical or non-physical in nature. When most people think about sports, they think of them as purely athletic endeavours that require only motor skills to flourish. However, research in the domains of sports, psychology, and physical education has proven that excelling physically is difficult without optimally developed mental or cognitive abilities. According to researchers, intentionally employing cognitive abilities will magnify them in turn [8] cognitive ability. Cognitive ability like working memory, which is the ability to hold information temporarily in a limited capacity [9], plays an important role in the skill acquisition and execution process, and cognitive ability like mindful attention, which is the ability to bring a person's attention to the present moment [10], helps an individual in properly allocating attentional resources to the most relevant stimuli and also in calming the mind from unwanted stress.

The most effective development of these skills becomes crucial because sports involve unpredictability in every aspect. Many other strategies have been employed by authors to increase cognitive capacities in athletes, including specifically designed equipment-based training [11, 12], video-based training [13], and others. None of the research focusing on athletes, however, used a combination of both mental and physical tasks to target cognitive abilities. Some of the main disadvantages of existing cognitive training approaches are that they are either too expensive or too hard to implement. This study uses a self-designed cognitive training plan that involves both light physical activity and cognitive activities, with the purpose of primarily targeting working memory and mindful attention.

2. Materials and Methods

2.1 Participants: The participants were selected purposively selected from Trivandrum district, Kerala state, India country. 24 sportsmen between the age range of 21-23 years (with a mean age of 22 years) were screened based on certain pre-set criteria *viz*. (a)should be involved in regular sporting activities; (b) should be physically and mentally sound; (c) willingness to be part of the study should be entirely voluntary. After screening for the criteria 14 participants were shortlisted and were randomly assigned to two groups (Experimental and Control, N=7 each).

2.2 Measures: The following instruments were used to obtain raw data on the effect of cognitive training on working memory and mindful attention.

a) **Demographic Information:** The participants' names, ages, willingness to engage in the study, injuries, and medical history were obtained through a self-administered open-ended questionnaire.

b) **Working Memory:** Working memory was measured using the Digit Span test. The Digit Span test is a simple measure of working memory capacity. Each subject is shown a series of numbers on the laptop screen, one series at a time (e.g., 73,734.7349, etc). There are two variations of the test, via the forward and backward digit span test. The forward version has been used in this study, where the subject has to recall and type the digits in the order in which they are displayed on the screen. For each subsequent trial sequence, the number of digits presented increases by one. There is no change in the number of digits available for the next trial if any digits are missing or they are in the wrong order following a failed trial. For a certain digit span, the job is finished if the subject fails to correctly answer two consecutive questions. It is the total number of consecutive digits that are correctly recalled that determines the final score. Originally, the test was administered verbally, but in this study the test was administered using a 14-inch laptop, screen 35cm away from the subject and with the help of the PsyToolkit programme (Based on the recommendations of other authors [16-18].

c) **Mindful Attention:** Mindful attention was measured using the Mindful Attention Awareness Scale (MAAS). It's a 15-item questionnaire developed by Brown and Ryan in 2003 and scored on a 6-point Likert-scale (6 = nearly never; 1 = very often) and is intended to assess the extent to which people are paying attention to particular stimuli (the most relevant) while performing multiple tasks. The final score is calculated by dividing the total number of questions (i.e., 15) by the total number of items (i.e., 15), a higher score indicates a better level of mindfulness ability [19].

2.3 Procedure: The aim and objective of the study, as well as the researcher's intention, were thoroughly conveyed to the participants and to their coaches and teachers prior to the start of the training. A trainer with a professional qualification in physical education (Specialising in sports psychology) was also recruited, and the entire process of the study was thoroughly explained in minute detail. In addition, the researcher held two practical sessions for the trainer to familiarise him with the testing and training processes. Following that, a demographic questionnaire and consent form were distributed to participants in order to collect the necessary information, and after screening those questionnaires, suiTable participants were selected and allocated to two distinct groups, namely the experimental group and the control group, followed by a pre-test. Each of the participants received 10-15 minutes of testing time. The experimental group participated in a three-week cognitive-based training programme (designed by the author), and after the treatment ended, a post-test was administered to determine the effect of the training. In addition, participants and coaches/teachers were guaranteed that any data or records gathered from them would be kept totally confidential. This study used a quasi-experimental (pre-test/post-test) descriptive research design.

2.4 Cognitive-based training programme used in the present study: The experimental group underwent training using a self-designed cognitive training programme that comprised modest physical activities as well as mentally demanding activities that targeted the cognitive domain (dual-tasking in nature). Especially prefrontal cortex [20], medial cortex [21] and parietal lobes [22] responsible for memory and attention related activities. The training programme was specifically designed with the intention of engaging working memory and mindful attention. Based on the recommendations of some previous studies the training was implemented for 25 minutes per session for three weeks (21 days continuous) [23, 24]. The training combines moderate and basic physical activities (taping the ball, throwing, and walking) with mentally demanding tasks (remembering and cancelling numbers) and mindfulness meditation, which is simple to administer and practise.

2.5 Cognitive Training Programme: Training using ball (in progression level) + numbers pasted on the wall and remembering those numbers (6 min.); 2 min. rest; Number cancellation+ Walking (6 min.); 1 min. rest+ Mindfulness meditation (10 min.); Finally reproducing the remembered numbers from the 1st activity (i.e., Training using ball).

Weekly plan for 3 weeks

Week 1: Tapping the tennis ball (one ball) on the ground using both the hands along with that reading the numbers pasted on the wall (large font) and when the trainer call out a number the subject has to throw the ball on that particular number (using preferred hand) then catch it back and again start tapping tennis ball on the ground using both the hands; Slow walking (in desired area) along with number cancellation (large font size); mindfulness meditation using the mindful breathing technique (i.e., to identify the breath while breathing in and out without any interruption to the breathing process) and finally the subject has to write down

the 7 numbers that the trainer has asked them to throw ball in the first activity in the same sequence as that of the trainer.

Week 2: Tapping the tennis ball (one ball) on the ground using both the hands along with that reading the numbers pasted on the wall (large font, and the number of numbers pasted on the wall will be increased) and when the trainer call out a number the subject has to throw the ball on that particular number (using preferred hand) then catch it back and again start tapping tennis ball on the ground using both the hands; Slow walking (in a designated zone pre decided by the trainer) along with that number cancellation (medium font size); mindfulness meditation using the mindful breathing technique (i.e., to identify the breath while breathing in and out without any interruption to the breathing process) and finally the subject has to write down the 9 words that the trainer has asked them to throw ball in the first activity in the same sequence as that of the trainer.

Week 3: Tapping two tennis balls on the ground using both the hands along with that reading the numbers pasted on the wall (medium font) and when the trainer call out a number the subject has to throw one ball on that particular number (using preferred hand) then catch it back and again start tapping both the balls again using both the hands; Brisk walking (in a designated zone pre decided by the trainer) along with number cancellation (small font size); mindfulness meditation using the mindful breathing technique (i.e., to identify the breath while breathing in and out without any interruption to the breathing process) and finally the subject has to write down the 11 words that the trainer has asked them to throw ball in the first activity in the same sequence as that of the trainer.

Note: For number cancellation activity the trainer calls out a number from the paper provided to the subjects and the subject has to strikeout those numbers from the paper.

2.6 Data analysis
IBM-SPSS 22 was used to assess the raw data. For all dependent variables, descriptive analysis (mean and standard deviation), normality analysis (the Shapiro-Wilk test), paired t-test and analysis of covariance (ANCOVA) were performed. The significance level was set at.05 levels in advance.

3. Results

Table 1: Descriptive statistics and paired t-test values of mindful attention and working memory

Dependent Variable	Groups	Pre-Test		Post-Test		T (7)	P
		Mean	SD	Mean	SD		
Mindful Attention	Control Group	3.932	.653	3.987	.621	-2.254	.065
	Experimental Group	3.300	1.101	3.771	1.008	-3.963*	.007
Working Memory	Control Group	5.285	.755	5.142	.899	.548	.604
	Experimental Group	5.285	.951	6.714	1.112	-7.071	.000

*Significant at 0.05 level

In the above Table 1, the mean scores pre-test and post-test for mindful attention are 3.932 & 3.987. (SD=.653 & .621) and 3.300 & 3.771 (SD=1.101 & 1.008) for the control and experimental groups, respectively. And for working memory are 5.285 & 5.142 (SD=.755& .899) and 5.285 & 6.714 (SD= .951 & 1.112) for the control and experimental groups, respectively. The obtained statical value of the paired t shows that the experimental group showed significant improvement in their mindful attention (T=-3.963, P=.007) and working memory (T=-7.071, P=.000) score post the cognitive training intervention for three weeks.

Table 2: ANCOVA of cognitive training on mindful attention and working memory (Post-Test) among control and experimental group with adjusted post-test mean

Dependent Variable	Groups	Mean Difference	F (1,11)	Sig.	η^2
Mindful Attention	Control (3.704)	-.351	8.122*	.016	.425
	Experimental (4.055)	.351			
Working Memory	Control (5.143)	-1.571	20.966*	.001	.656
	Experimental (6.714)	1.571			

*Significant at 0.05 level

Table 2, A one-way ANCOVA was conducted to compare the effect of cognitive training on mindful attention & working memory (post-test) while controlling for mindful attention & working memory (pre-test). Levene's test and normality checks were carried out and the assumptions met. the result of the ANCOVA reveals that there is a statistically significant difference in mindful attention & working memory (post-test) [F(1,11)=8.122, p<.05(.016), Partial η^2=.425] & [F(1,11)= 20.966, p<.05(.001), Partial η^2=.656] respectively while controlling mindful attention & working memory (pre-test) between the groups (i.e., control and experimental groups). The mean difference after adjusting the mean for pre-test also showed that there is a statistically significant difference between the post-test scores of the control and experimental groups on the dependent variables mindful attention & working memory due to the effect of the independent variable (cognitive training). For instance, the experimental group significantly improved from that of the control group in mindful attention with a mean difference of .351 (P=.016) and working memory with a mean difference 0f 1.571 (P=.001). The Partial η^2 value for mindful attention when compared with the Cohen's guidelines (0.2-small effect, 0.5-moderate effect, 0.8-large effect) indicated a small effect size (Partial η^2=.425). The partial η2 value showed a 42.5% variance in the mindful attention (post-test) between the control and experimental groups while controlling the pre-test scores. And for working memory showed moderate effect size (Partial η^2=.656). The partial η2 value showed a 65.6% variance in the working memory (post-test) between the control and experimental groups while controlling the pre-test scores.

4. Discussion
The current paper examines the effect of cognitive training on mindful attention and working memory among sportsmen. Given that successful careers in sports and producing winning or record-breaking performances demand slightly better cognitive skills than those of the average person [25], it is obvious that it is important to develop cognitive abilities that go beyond those that are innate or learned through experience. Just as physical training increases physical ability, mental or cognitive training increases mental ability. This idea is directly supported by the science of neuroplasticity, which is the brain's innate capacity for dynamic change through the formation and rebuilding of new neural connections and networks, or more simply put, through simple learning [26]. In contrast to the availability and expense of equipment for doing physical training, equipment for performing brain or cognitive training is restricted and expensive. When examined in the context of India, it becomes much rarer, as these

advanced equipment's needs to be imported from foreign nations and is costly, making its accessibility rarer in India. A lack of information surrounding sports psychology and the significance and advantages of such training also adds to the current issue.

Through this study, the author aimed to find the effect of a self-designed cognitive training programme on the mindful attention and working memory abilities of the sportsmen. The cognitive training programme was devised following a comprehensive literature study and assistance from professionals in the field of sports psychology. The cognitive training programme is simple to administer, requires relatively simple equipment, and can be completed in a short space (which in the Indian context is an important element). After three weeks of training (21 consecutive days), the experimental group's mindful attention and working memory performance rose more than those of the control group. The large rise in the sportsmen's mindful attention and working memory may be due to the study's new dual-tasking cognitive training strategy, which combined physical and cognitive features in a simultaneous manner. The findings that cognitive training increases working memory gain support from the findings of Wu Y, *et al.*, 2023 [27] and Riker, *et al.*, 2022 [28], who, after analysing numerous studies, discovered that combining cognitive training with physical activity training improves working memory.

The findings that cognitive training increases mindful attention may be attributed to the novel dual-tasking cognitive training design, as there were specific training elements (mindfulness meditation) in the cognitive training design that might have aided this improvement. Some studies that used mindfulness meditation as an intervention also found that it affected the cognitive domain [29, 30]. And in a systematic review by Farhang *et al.*, 2019 [31], they found that mind-body interventions improve mindfulness, although their target population was older adults.

Additionally, there are no similar studies incorporating a similar cognitive training design, methodology, and evaluation protocol with sportsmen as the key population, there are numerous studies that inquire about the effectiveness of cognitive training on various cognitive abilities in a varied subject population, and almost all of the studies found promising results. Furthermore, research that used cutting-edge brain mapping equipment (EEG) with proper scientific protocols as a testing tool found that as a result of brain training or cognitive training, certain brain regions are getting increased activity, and regions that were dormant before training showed signs of activation after training [32].

5. Conclusion

In conclusion, the authors suggests that any athlete who wants to develop their cognitive abilities (particularly mindful attention and working memory) ought to consider the training programme employed in this study, as this will be reflected in their athletic performance. The findings of Verburgh *et al.*, 2014 [33]; Cona *et al.*, 2015 [34]; Walton *et al.*, 2018 [35]; and Scharfen and Memmert, 2019 [36] corroborate the claim that cognitive training will increase sporting performance. The most significant problem in this study is the lack of adequate testing techniques, as expensive technology is required to evaluate minute and exact improvements in the brain. Which, in the Indian context, is neither available nor viable if one wishes to obtain it (costly and unavailable in the Indian market). Future study should focus on developing individualised training programmes that incorporate various cognitive training modalities while striving to precisely target distinct cognitive processes (Which are required of athletes depending on the sport they play).

6. Ethical considerations/statement

Participation was fully optional, with the ability to drop out at any time during the study. Secrecy was maintained. There were no biochemical or other biometric samples taken from the individuals. All the guidelines were followed as per Helsenki's declaration. The regular academic and athletic schedules of the participants were not disrupted. In addition to gaining prior approval from the coaches and teachers, their attendance throughout the training sessions was ensured so that they could voice any reservations. An internal ethical committee has approved this study's ethics.

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8. Conflict of interest

The authors declares that there is no conflict of interest.

9. Reference

1. The Importance of Cognition in Determining Who We Are. Verywell Mind. 2023 Apr 18. Available from: https://www.verywellmind.com/what-is-cognition-2794982
2. Jaeggi SM, Buschkuehl M, Jonides J, Shah P. Short- and long-term benefits of cognitive training. Proc Natl Acad Sci. 2011 Jun 13;108(25):10081-10086. DOI: 10.1073/pnas.1103228108
3. Al-Thaqib A, Al-Sultan F, Al-Zahrani A, Al-Kahtani F, Al-Regaiey K, Iqbal M, *et al.* Brain training games enhance cognitive function in healthy subjects. Med Sci Monit Basic Res. 2018 Apr 20;24:63-69. DOI: 10.12659/MSMBR.909022
4. Bluma BI, Lipowska M. Physical activity and cognitive functioning of children: A Systematic Review. Int J Environ Res Public Health. 2018 Apr 19;15(4):800. DOI: 10.3390/ijerph15040800
5. Can Cognitive Training Really Lead to Lasting Mental Improvement? Verywell Mind; c2021 Feb 6. Available from: https://www.verywellmind.com/cognitive-training-long-term-improvement-2795014
6. Zahra FF, Alireza F, Mohammad M, Vaez K, Hojjat S, Zamani S. Effect of cognitive training on efficiency of executive control network of attention. J Res Rehabil Sci. 2015;11(3):182-192. DOI: 10.22122/jrrs.v11i3.2155
7. Fuchs BA, Martyr A, Goh AM, Sabates J, Clare L. Cognitive training for people with mild to moderate dementia. Cochrane Database Syst Rev; c2019 Mar 25. DOI: 10.1002/14651858.CD013069.pub2
8. Baker J, Young B. 20 years later: Deliberate practice and the development of expertise in sport. Int Rev Sport Exerc Psychol. 2014;7(1):135-157. DOI: 10.1080/1750984X.2014.896024
9. Zaichkowsky L, Peterson D. The Playmaker's Advantage: How to Raise Your Mental Game to the Next Level. Simon and Schuster.
10. Miyake A, Shah P. Models of working memory: Mechanisms of Active Maintenance and Executive Control. Cambridge: Cambridge University Press; c1999. ISBN 978-0-521-58325-1.
11. Khoury G. Mindful attention, a component of mindfulness. Eastwood Schools. 2018 Mar 21. Available

from: https://eastwoodschools.com/mindful-attention-component-mindfulness/
12. Bhosle S, Acharya J. Effect of cognitive interventions and proprioceptive training on psychomotor attributes among female athletes. Lakshmibai National Institute of Physical Education; c2017. http://hdl.handle.net/10603/289930
13. Zhou Y, Chen CT, Muggleton NG. The effects of visual training on sports skill in volleyball players. Progress Brain Res; c2020. p. 201–227. DOI: 10.1016/bs.pbr.2020.04.002
14. Larkin P, Mesango C, Spittle M, Berry J. An evaluation of video-based training programs for perceptual-cognitive skill development. A systematic review of current sport-based knowledge. Int J Sport Psychol. 2015;46(6):555-586. DOI: 10.7352/IJSP.2015.46.555
15. Stoet G. PsyToolkit. Teach Psychol. 2016 Nov 15;44(1):24-31. DOI: 10.1177/0098628316677643
16. Stoet G. PsyToolkit: A Novel Web-based method for running online questionnaires and reaction-time experiments. Teach Psychol. 2017;44:24-31. DOI: 10.1177/0098628316677643
17. Stoet G. PsyToolkit: A software package for programming psychological experiments using Linux. Behav Res Methods. 2010 Nov;42(4):1096–1104. DOI: 10.3758/brm.42.4.1096
18. Lee KJ, Park CA, Lee YB, Kim HK, Kang CK. EEG signals during mouth breathing in a working memory task. Int J Neurosci; c2019. DOI: 10.1080/00207454.2019.1667787
19. Brown KW, Ryan RM. The benefits of being present: Mindfulness and its role in psychological well-being. J Pers Soc Psychol. 2003;84(4):822–848. DOI: 10.1037/0022-3514.84.4.822
20. Funahashi S. Working Memory in the Prefrontal Cortex. Brain Sciences. 2017 Apr 27;7(12):49. DOI: 10.3390/brainsci7050049
21. Marchand WR. Neural mechanisms of mindfulness and meditation: Evidence from neuroimaging studies. World J Radiol. 2014;6(7):471. DOI: 10.4329/wjr.v6.i7.471
22. Valk SL, Bernhardt BC, Trautwein FM, Böckler A, Kanske P, Guizard N, *et al.* Structural plasticity of the social brain: Differential change after socio-affective and cognitive mental training. Sci Adv; c2017 Oct 6, 3(10). DOI: 10.1126/sciadv.1700489
23. Nouchi R, Taki Y, Takeuchi H, Hashizume H, Akitsuki Y, Shigemune Y, *et al.* Brain training game improves executive functions and processing speed in the elderly: A randomized controlled trial. PloS one. 2012;7(1):e29676. DOI: 10.1371/journal.pone.0029676
24. Al-Thaqib A, Al-Sultan F, Al-Zahrani A, Al-Kahtani F, Al-Regaiey K, Iqbal M, *et al.* Brain training games enhance cognitive function in healthy subjects. Med Sci Monit Basic Res. 2018. DOI: 10.12659/msmbr.909022
25. Mendo HA, Reigal RE, Walle LJM, Serpa S, Samdal O, Sánchez MV, *et al.* Physical Activity, sports practice, and cognitive functioning: The Current Research Status. Front Psychol; c2019. DOI: 10.3389/fpsyg.2019.02658
26. Costandi M. Neuroplasticity. The MIT Press; c2016. ISBN: 9780262529334
27. Wu Y, Zang M, Wang B, Guo W. Does the combination of exercise and cognitive training improve working memory in older adults? A systematic review and meta-analysis. Peer J. 2023;11:e15108. DOI: 10.7717/peerj.15108
28. Rieker JA, Reales JM, Muiños M, Ballesteros S. The Effects of combined cognitive-physical interventions on cognitive functioning in healthy older adults: A Systematic Review and Multilevel Meta-Analysis. Front Hum Neurosci; c2022 Mar 24. DOI: 10.3389/fnhum.2022.838968
29. Whitfield T, Barnhofer T, Acabchuk R, Cohen A, Lee M, Schlosser M, *et al.* The Effect of Mindfulness-based Programs on Cognitive Function in Adults: A Systematic Review and Meta-analysis. Neuropsychol Rev. 2021 Aug 4;32(3):677–702. DOI: 10.1007/s11065-021-09519-y
30. Lenze EJ, Voegtle M, Miller JP, Ances BM, Balota DA, Barch D, *et al.* Effects of Mindfulness Training and Exercise on Cognitive Function in Older Adults. JAMA. 2022 Dec 13;328(22):2218. DOI: 10.1001/jama.2022.21680
31. Farhang M, Miranda-Castillo C, Rubio M, Furtado G. Impact of mind-body interventions in older adults with mild cognitive impairment: A systematic review. Int Psychogeriatr. 2019;31(5):643–666. DOI: 10.1017/S1041610218002302
32. Parsons B, Magill T, Boucher A, Zhang M, Zogbo K, Bérubé S, *et al.* Enhancing Cognitive Function Using Perceptual-Cognitive Training. Clin EEG Neurosci. 2016;47(1):37–47. DOI: 10.1177/1550059414563746
33. Verburgh L, Scherder EJA, van Lange PA, Oosterlaan J. Executive Functioning in Highly Talented Soccer Players. PLOS ONE. 2014;9(3):e91254. DOI: 10.1371/journal.pone.0091254
34. Cona G, Cavazzana A, Paoli A, Marcolin G, Grainer A, Bisiacchi PS. It's a Matter of Mind! Cognitive Functioning Predicts the Athletic Performance in Ultra-Marathon Runners. PLOS ONE. 2015;10(7):e0132943. DOI: 10.1371/journal.pone.0132943
35. Walton CC, Keegan RJ, Martin M, Hallock H. The Potential Role for Cognitive Training in Sport: More Research Needed. Front Psychol; c2018. DOI: 10.3389/fpsyg.2018.01121
36. Scharfen HE, Memmert D. The relationship between cognitive functions and sport-specific motor skills in elite youth soccer players. Front Psychol; c2019. DOI: 10.3389/fpsyg.2019.00817